Space Weather Technical Forecast

Issued on Sunday, 20 February 2022 at 01:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/Minor Geomagnetic Storms likely day 1 or 2 (20th/21st). Chance of Active fluence day 3 onward.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with a C1 flare observed from a region over the northeast limb, perhaps returning AR2938 which was a likely source of a notable far-sided flare and CME on the 15th. There are 3 Earth-sided sunspots regions, however these are all small and simple, including AR2948 Cso/Beta, AR2952 Axx/Alpha and AR2953 Bxo/Beta, which is the only region currently showing some slow growth. There was a filament eruption in the southeast disc, which has produced a CME which has yet to be assessed. Given its location, this will likely miss Earth, but will need further images for a more certain assessment. No other Earth-directed CMEs have been observed

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, rose briefly to from background levels of 320 km/s to 380km/s around 19/0900 UTC, before easing again to background by 19/1200 UTC. A more erratic increase then occurred, reaching 450 km/s by midnight. The initial rise was accompanied by above average density since 19/0200 UTC of 10-17 ppcc, but was otherwise at average from 19/1200-2120 UTC, before becoming above average again thereafter. The total magnetic field strength (IMF) Bt, rose from 7nT to 10nT with the initial density rise, then fell to 5nT, then rose with the speed increase to around 8-10nT. This was accompanied with a smooth Bz (North-south component) rotation, from -5nT to neutral by midday. Bz was then notably more erratic but still weak, with some brief positive values until a further increase in Bt to 9-12nT from 19/2100 UTC was accompanied with Bz becoming moderately negative, peaking -10nT. Phi angle was negative throughout (towards the Sun) but became variable from 19/2100 UTC. These parameters suggest a weak transient moved through 19/0200-1200 UTC, followed by the arrival of the CIR of CH55/-. Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (10MeV) measured at GOES 16 has tracked slightly above background levels after a very large and energetic flare and CME seen on coronagraph imagery from the rearward eastern solar hemisphere on 15 February. The high energy electron flux (greater than 2MeV) has been at background levels. The corresponding 24-hour integrated electron fluence was initially Active (above 1e8 integrated pfu) but fell below this level by 19/0900UTC. The 20/0000 UTC observation was 1.58e6 pfu

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Low or Very Low at first, but with a slight chance of rising to Moderate due to the potential for flaring from a notable region just around the limb, which is anticipated to rotate onto the Earth-facing disc day 2 (21st). The three sunspot regions on the Earth-facing disc are currently unlikely to produce significant flares.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Earth is likely in the CIR ahead of the fast wind of CH55/-, and expected to move into the fast wind day 1 (20th). A further enhancement is then likely day 2 (21st) from the arrival of the fast wind of CH56/+, with fast winds perhaps persisting day 3 (22nd) before easing day 4 (23rd). Geomagnetic activity is

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forecast to become Unsettled to Active day 1 and day 2 (20th to 21st), with G1 Minor Storm intervals likely. Otherwise, mainly Quiet to Unsettled, with only a chance of Active intervals day 3 (22nd).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to soon fall to background levels and then persist at these levels. The high energy (greater than 2 Mev) electron flux is currently at background, but has a chance of increasing later day 2 (21st) but more likely day 3 and 4 (22nd and 23rd), becoming Moderate with a chance of peaking at High (greater than 1000 pfu). The associated fluence will likely rise as a result, with a chance of reaching the Active threshold (1e8 integrated pfu) by the end of day 3 (22nd).

Figure 1: L1 Solar wind observations for 19th (DSCOVR)

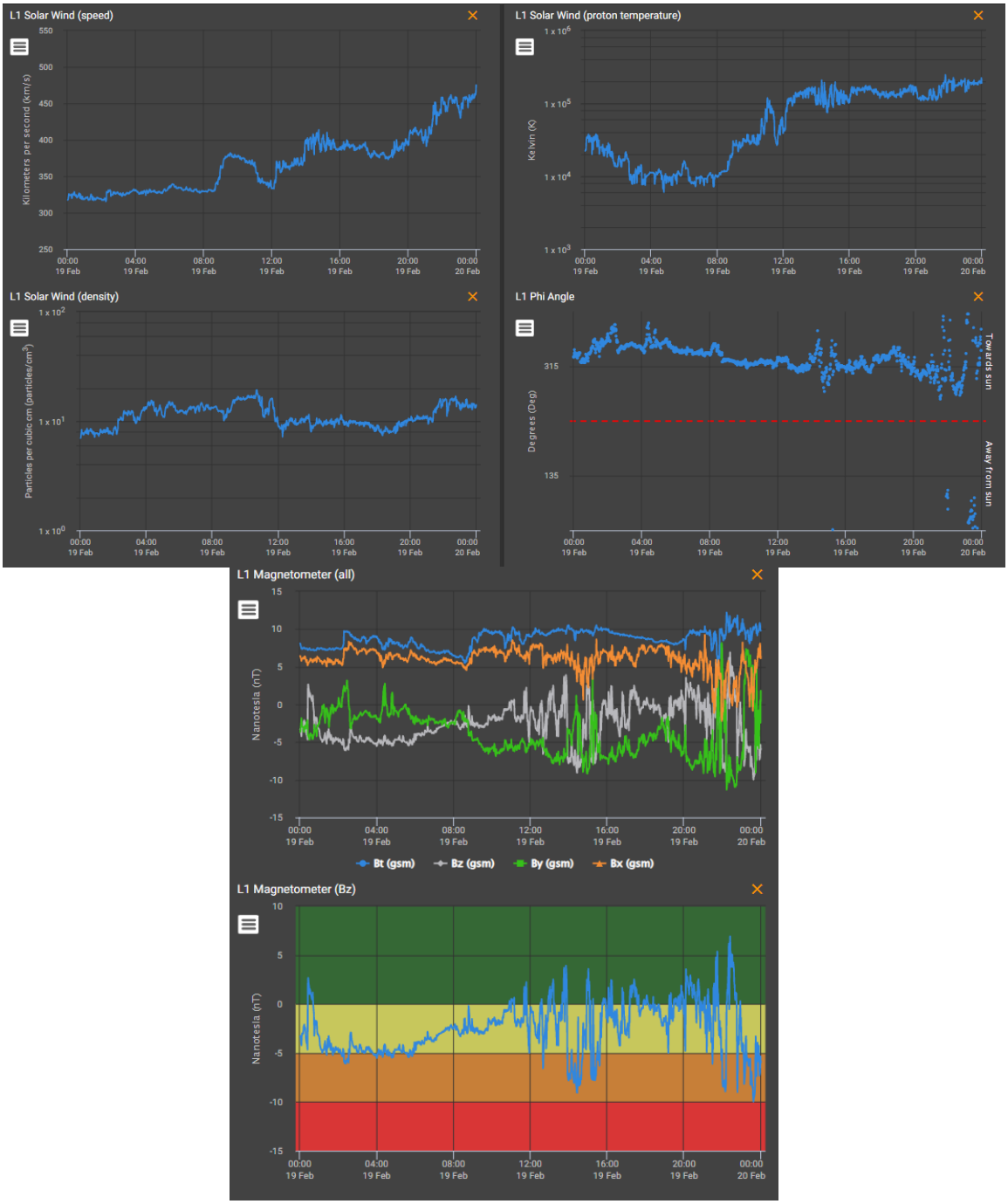

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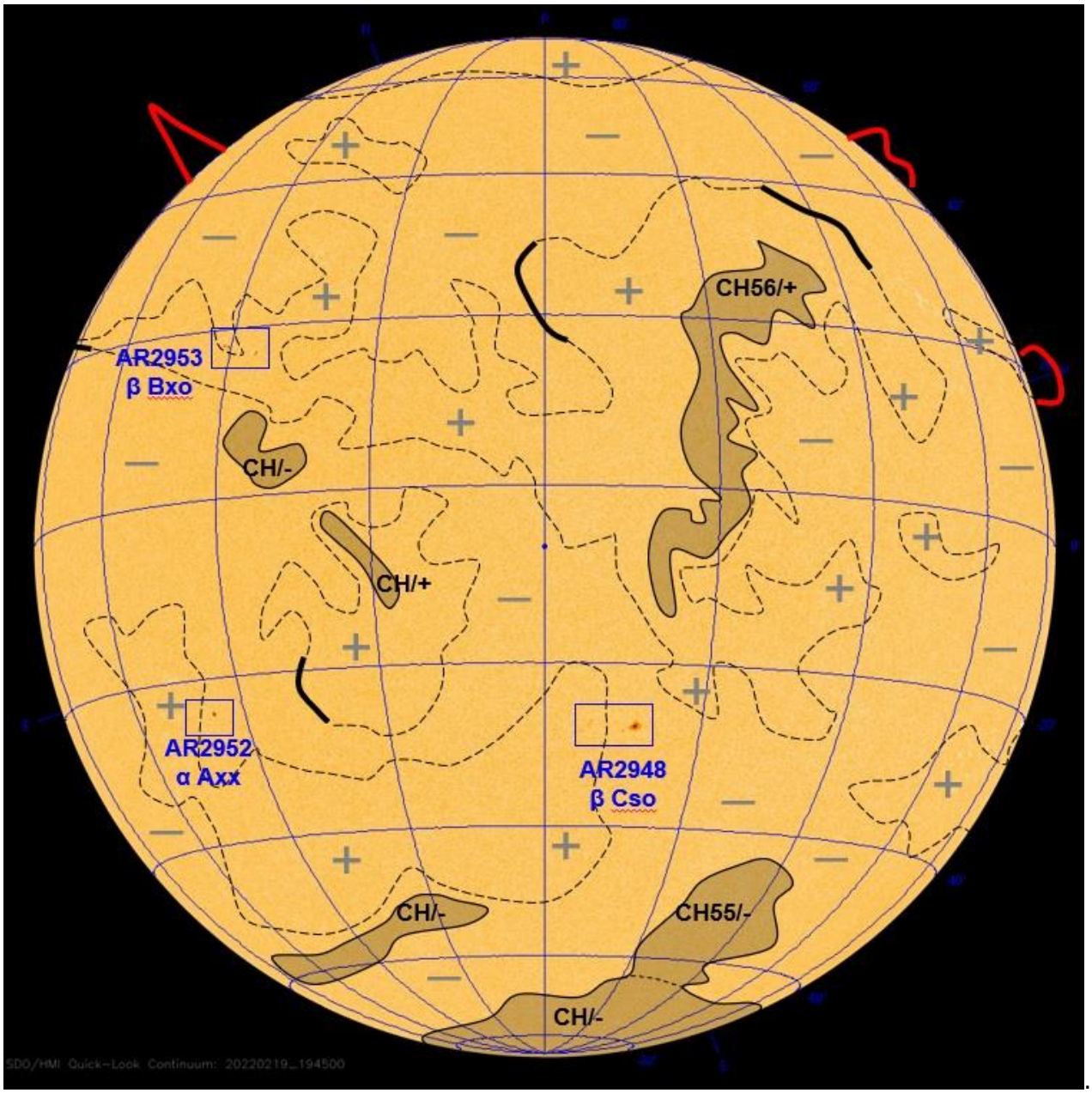
Figure 2. Solar Analysis Valid 19/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs.

Solar winds are currently slightly elevated, and increasing, potentially due to an early arrival of the CIR ahead of the fast wind of CH55/-, a northward extension of the southern polar crown coronal hole. This is slightly ahead of another more central disc coronal hole CH56/+, in terms of longitude, which enlil suggests arriving after CH55/-, either late 20th or early 21st. 27-day persistence has the arrival of any fast wind on the 21st, however there was only the positive central coronal hole on the previous rotation. While STEREO A PLASTIC data does show an enhancement during the equivalent period, this is of limited value as it is contaminated by a potential CME arrival at the spacecraft across the 17th/18th.

Consequently. a period of geomagnetic disturbance is likely during day 1 and day 2 (20th and 21st) with solar winds expected to become elevated at 500-600 km/s. Fast winds are then expected to persist day 3 (22nd), only gradually easing day 4 (23rd). Geomagnetic activity is forecast to become Unsettled to Active day 1 and day 2 (20th to 21st), with G1 Minor Storm intervals likely. Otherwise, mainly Quiet to Unsettled, with only a chance of Active intervals day 3 (22nd).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	40	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 3: Solar Wind Persistence Model

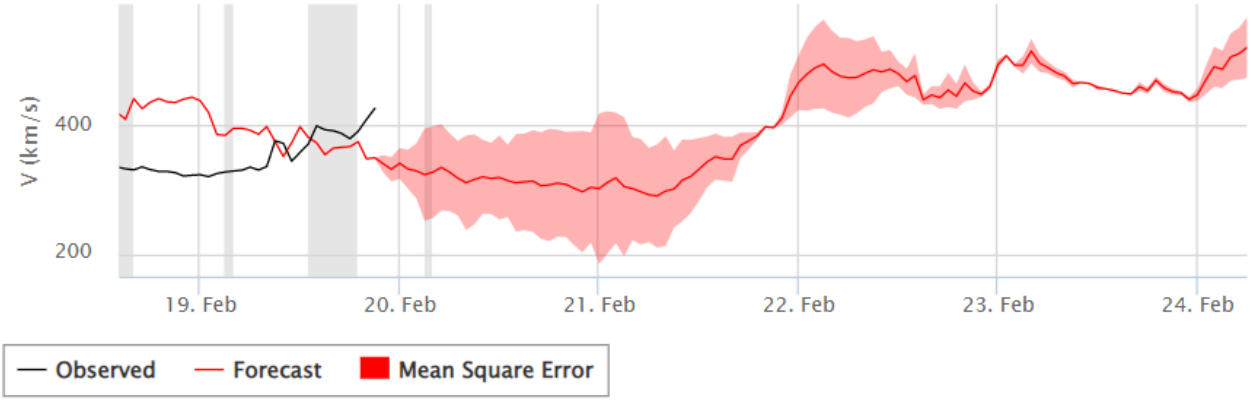

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Figure 4: SDO aia-193 of previous rotation (left) and current rotation (right). No visible southern CH last rotation and central CH slightly further ahead.

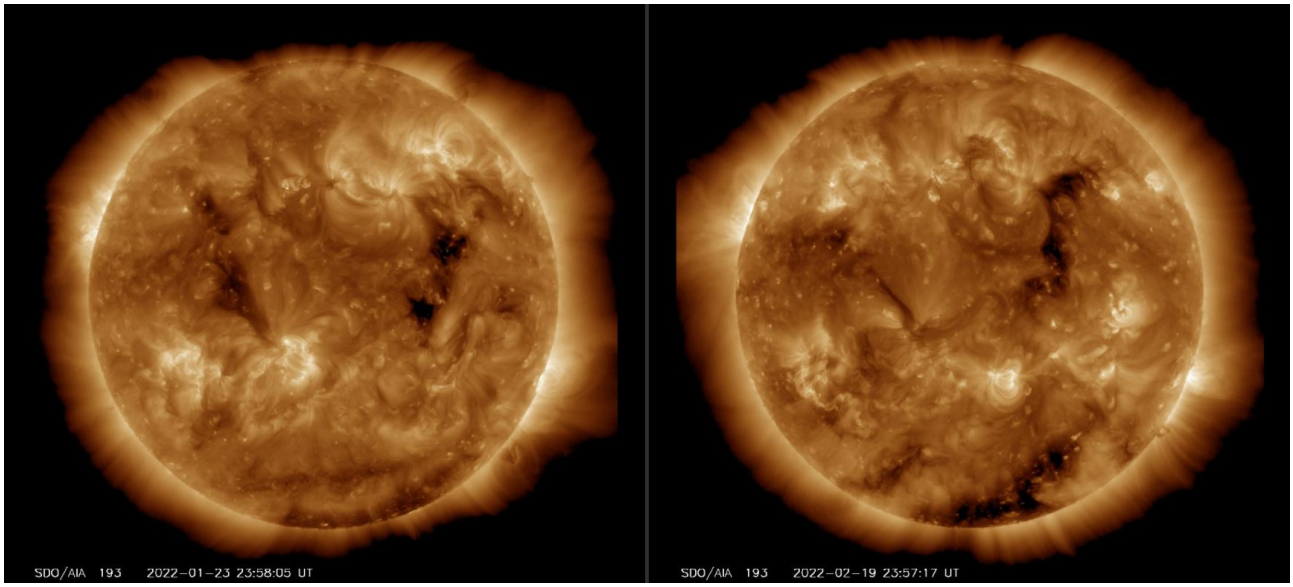
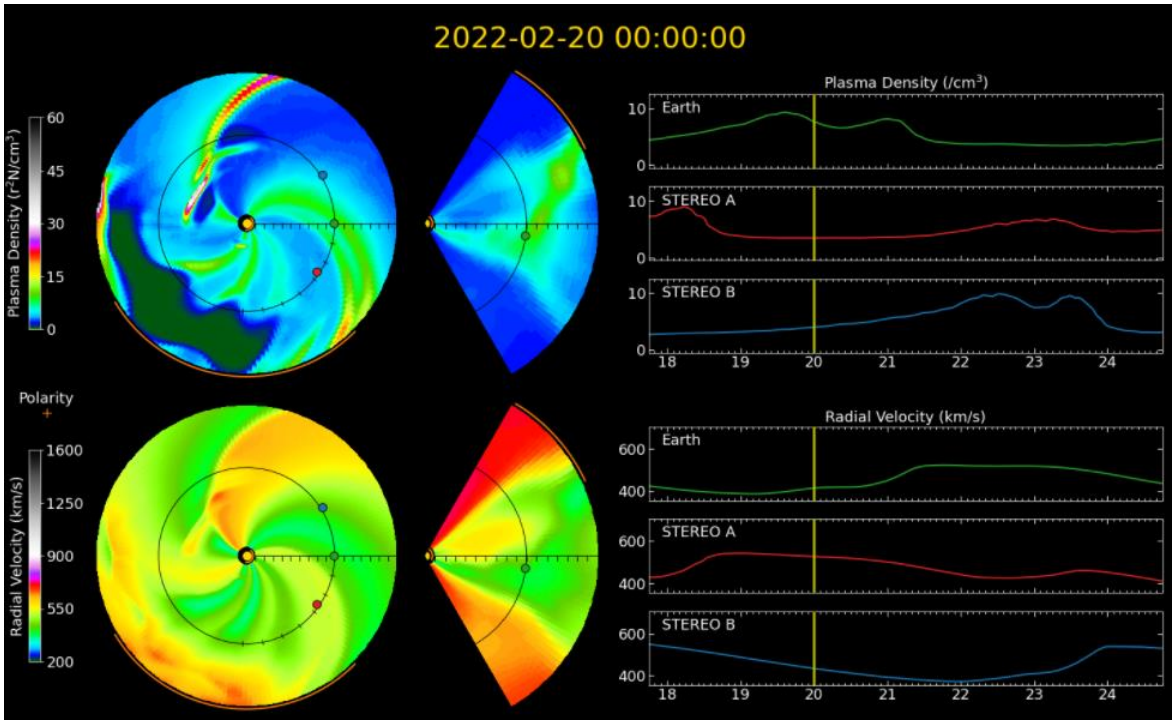


Figure 5: Enlil showing arrival of solar winds through the 20th and 21st. (Note large and fast far-side CME clearly visible).



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Radio Blackouts - X-Ray Flares:

There are only three small and simple sunspots on the disc, however solar activity is currently Low due to a C1-flare from just over the northeast limb. AR2948 Cso/Beta is the most complex sunspot region, just west of the southern central disc, but largely inactive, small and currently showing signs of decay with trailer spots now very difficult to observe. AR2952 in the southeast is a stable, but very small Axx/alpha spot. AR2953 in the northeast is showing some sign of slow development, with emergent intermediate spots, but remains a simple Bxo/Beta for now. Significant flares from these regions are currently unlikely with Low to Very Low activity expected.

Magnetic looping is also visible on the northeast limb in SDO imagery, associated with an active region(s) expected to rotate onto the disc during the coming 24-48 hours. This is a notably bright area on STEREO-A euvi, and potentially corresponds to the source of an energetic flare and CME on the far side on the 15th. This also corresponds to a large and strong helioseismic signal, on far-side imagery, albeit one that is weakening as it approaches the east limb, perhaps indicative areas of more diffuse plage. Furthermore, this signal is not expected on the limb until the 21st, suggesting the main risk may be from a second region following the looping that is visible on SDO. Either way, flares from just over the limb have the potential to be observed at Earth, giving a slight chance of M-flares and activity increasing to Moderate.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	10	10	10	10
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 6: GOES-16/17 X-ray Flux

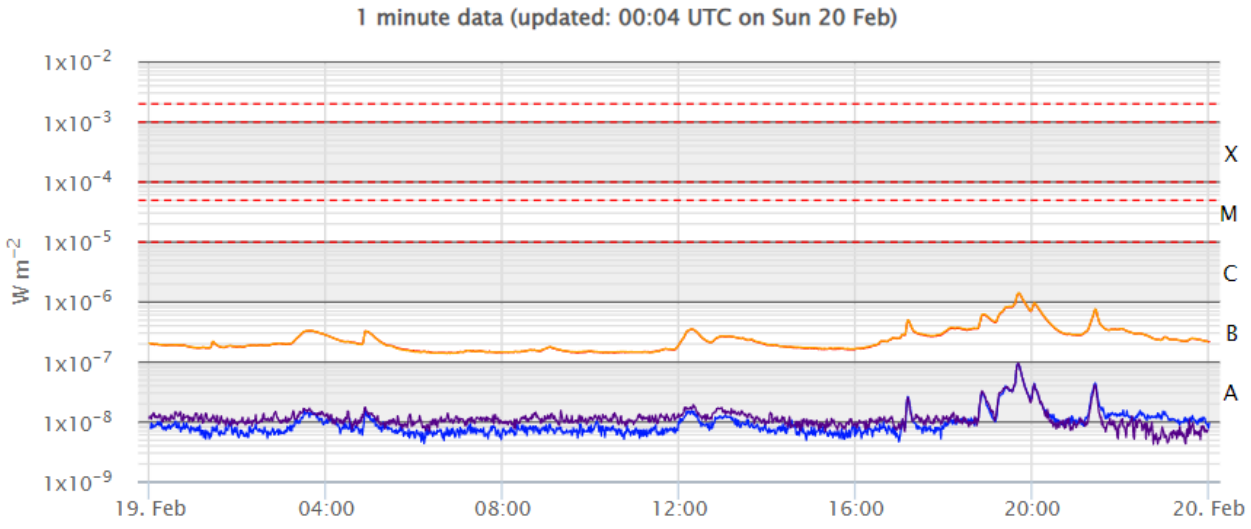

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Figure 7: SDO aia-94 showing location of C1-flare (left) with STEREO-A euvi of same flare (right)

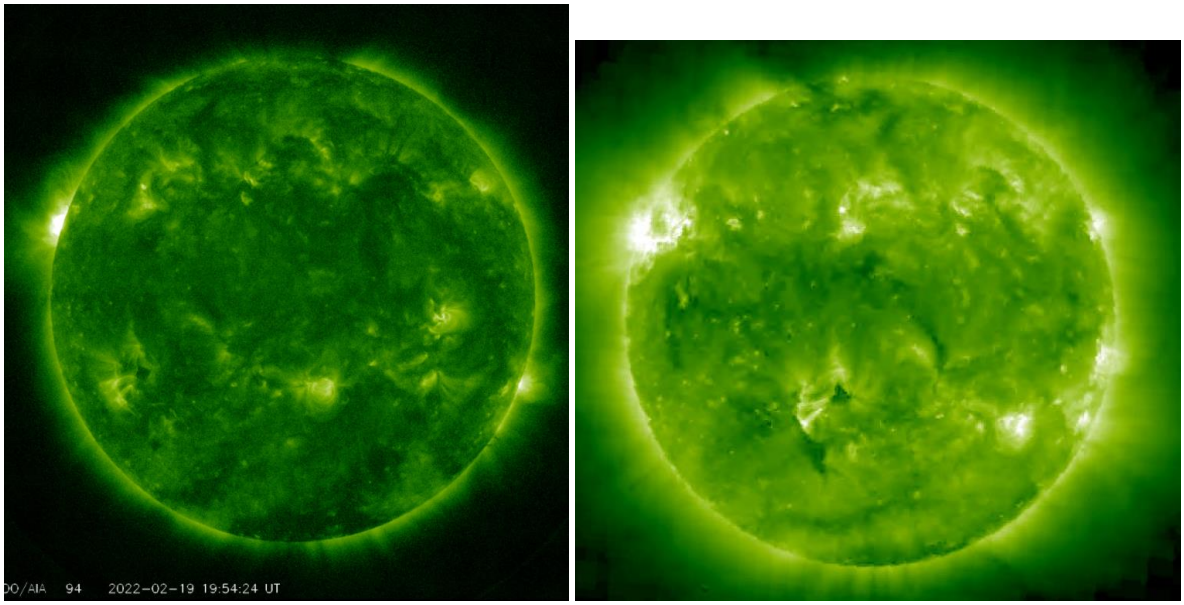
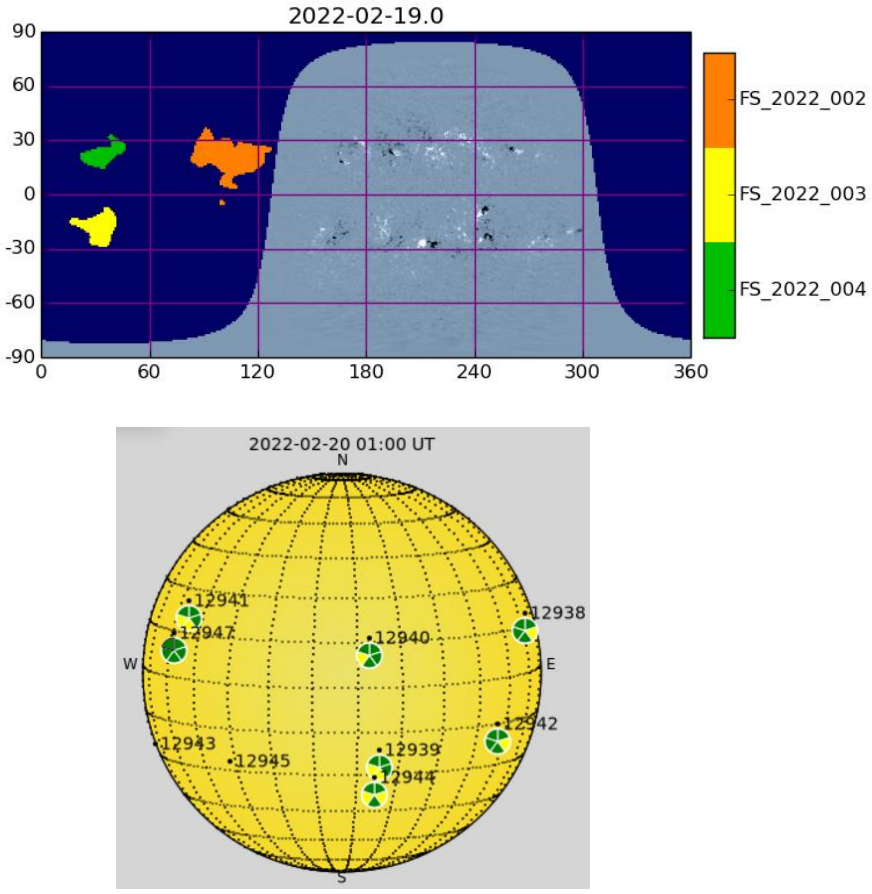


Figure 8: Helioseismic far-side map, showing strong region near limb (top – orange). This coincides with returning AR2938 as shown on Raben map (bottom)



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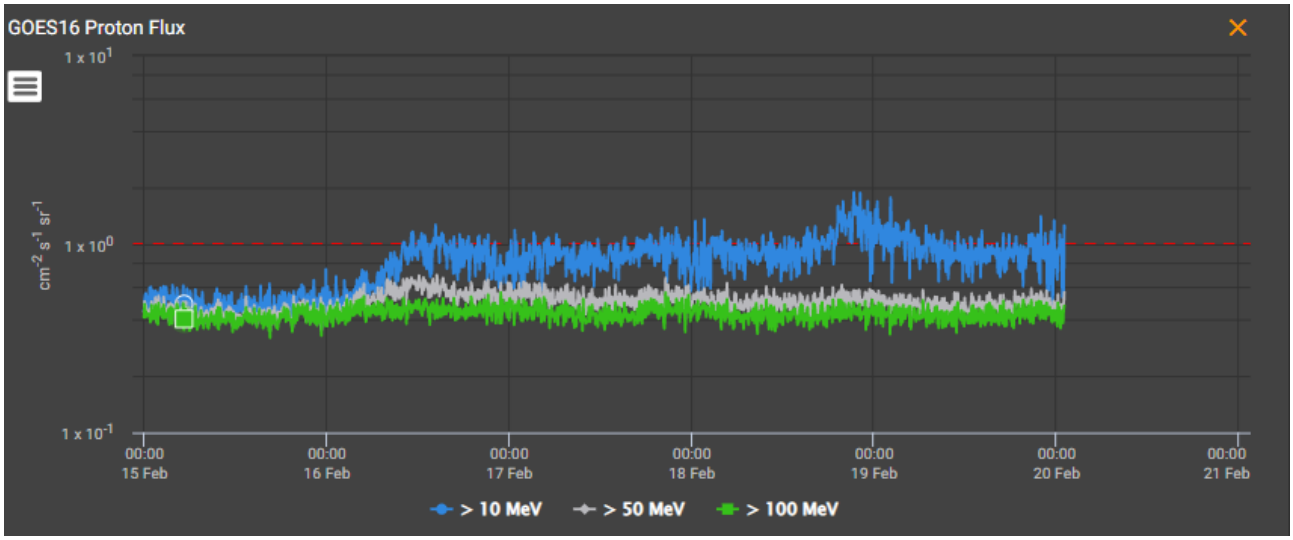
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 has tracked slightly above background levels since 18/1200UTC, but is now on a gradual declining trend towards background. The enhanced activity was due to a very large and energetic flare and CME seen on coronagraph imagery from the rearward eastern solar hemisphere on the 15th. This region is due to rotate onto the Earth-side disc on the 21st, but has not exhibited any further significant activity since this flare. Furthermore, energetic protons are largely guided along the Parker spiral, and consequently radiation storms are notably less likely from the eastern limb for all except the largest flares. Until we can fully assess an ongoing flare risk from this region, the chance of proton storms (S1, which is greater than 10pfu) is maintained at background.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 9: GOES-16 Proton Flux, showing slightly above average since the 16th.



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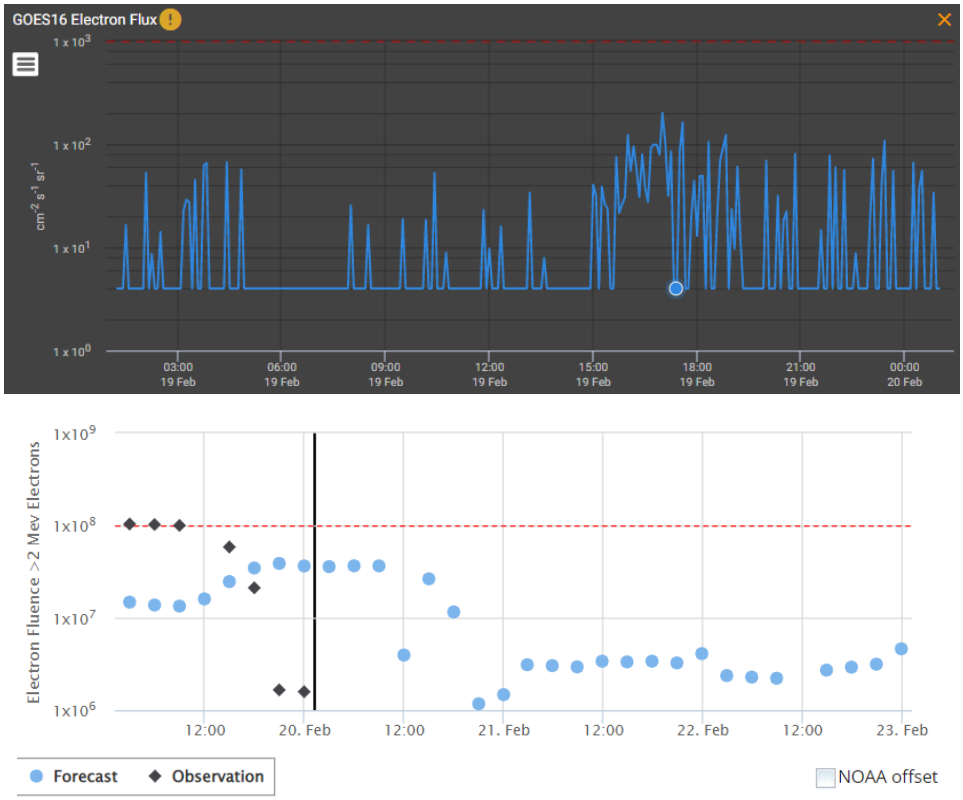
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2 MeV) as observed by GOES-16 at GEO is currently at background, having dropped out on the 19th. With solar winds forecast to increase through day 1 (20th), and then potentially being enhanced again on day 2 (21st) by sequential coronal hole fast wind arrivals, periods of Moderate flux are possible day 1 and 2, perhaps peaking at High (greater than 1000 pfu) day 2. On day 3 (22nd) and 4 (23rd), more persistently Moderate to potentially High flux is forecast.

The associated 24 hour Fluence is currently below the Active threshold, but likely to rise through the period, albeit erratically and minimally day 1 (20th), before more persistently Moderate to perhaps High flux gives a chance of reaching the Active threshold, most likely day 3 or day 4 (22nd and 23rd). REFM, whilst below the Active threshold throughout, is likely to be poor guidance, as this doesn't take account of the expected fast wind arrivals.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	1	20	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 10: GOES-16 Electron Flux and Fluence with REFM.



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